

TSA PROCEDURE – APPLICATION OF THERMAL SPRAY COATINGS

1.0 PURPOSE

To assure safe application of Thermal Spray Coatings (TSC) most commonly aluminum, zinc, zinc/aluminum and stainless steel. Thermal spraying is a process that deposits molten and semi-molten metallic materials onto a prepared surface using specialized arc spray (see Figure 1) or flame spray (see Figure 2) equipment. TSC has been categorized as a flame type hot work process.

2.0 GENERAL GUIDELINES

WARNING: EXTREME FIRE AND EXPLOSION HAZARD

Thermal Spray Coatings (TSC) flame spray applications use pure oxygen. Pure oxygen behaves differently than air; it can be very reactive when exposed to incompatible materials. It also creates a condition called oxygen enrichment. The main danger in oxygen enriched environments is that work clothing or other normally hard to ignite items can easily catch fire. Some materials such as hydrocarbons, lubricants and other contaminants react explosively if they come into contact with pure oxygen at higher pressures. To avoid serious injury, use only materials and components approved for oxygen service and follow the guidelines below.

- 2.1 Thermal Spray is a safe process when operators are trained and knowledgeable about the specific processes and materials, and the equipment has been installed and maintained according to the manufacturers' recommendations. Brand utilizes training courses offered by the equipment supplier to obtain theoretical background and practical experience in the various thermal spray processes. For additional information regarding training or equipment maintenance, please contact the service department or your equipment supplier.
- 2.2 It is required that all personnel connected with thermal spraying become familiar with the safety practices outlined in this procedure as well as the established standards and regulations which have been set by local, state and federal health officials.
- 2.3 There are several basic precautions for thermal spraying which should always be observed. These include: good housekeeping, proper material/gas storage and handling practices, use and maintenance of equipment, equipment checklist, operator training, and proper ventilation by providing sufficient exhaustion of gases and fumes, and personal protective equipment (PPE) for skin ears, eyes and respiratory protection.
- 2.4 It is important to note that although some thermal spray materials can be hazardous, safe operating and environmental conditions can be achieved through the use of proper ventilation equipment, training, and personal protective equipment. Certain spray conditions may also require the additional use of HEPA filtration.
- 2.5 All users of flame spray and arc spray equipment and processes must become familiar with and obtain the necessary information to safely operate their equipment at their location.

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- 2.6 The facility or project location must receive the appropriate environmental permit and or state approval prior to beginning work. Brand management must be informed of anticipated work scope to facilitate where necessary an approval from the state environmental agency.

3.0 FIRE PREVENTION BASICS

WARNING: EXTREME FIRE AND EXPLOSION HAZARD

Thermal Spray Coatings (TSC) flame spray applications use pure oxygen. Pure oxygen behaves differently than air; it can be very reactive when exposed to incompatible materials. It also creates a condition called oxygen enrichment. The main danger in oxygen enriched environments is that work clothing or other normally hard to ignite items can easily catch fire. Some materials such as hydrocarbons, lubricants and other contaminants react explosively if they come into contact with pure oxygen at higher pressures. To avoid serious injury, use only materials and components approved for oxygen service and follow the guidelines below.

- 3.1 When handling liquefied gas, use the NFPA 58, NFPA 55, NFPA 50, NFPA 50B, and OSHA code 29 CFR 1910.101 and 1910.253 Standard for the Storage and Handling of Compressed Gases as guidelines.
- 3.2 Airborne metal dust accumulation should be treated as a potential explosion hazard (especially zinc, aluminum, dust, although most finely divided metal powders may exhibit explosive reactions).
- 3.3 To minimize the danger of explosions adequate ventilation systems must be a consideration for work in enclosed spaces and is dependent on the work environment. Good housekeeping in the work area should be maintained so as to limit the accumulation of paper, rags and metal dust build-up.
- 3.4 When working in a shop environment, check all booth tops and overhead pipes, dust collection system and vacuum booth walls weekly and never allow an accumulation of dust. When using dry filter cartridge dust collectors they should be used only after consultation with those experienced and knowledgeable in these type systems.
- 3.5 When using dry filter cartridge dust collectors they should be used only after consultation with those experienced and knowledgeable in these type systems.

4.0 ELECTRIC POWER PRECAUTIONS (ARC SPRAY)

- 4.1 Electrical installations shall be made in accordance with local and state code requirements as well as the National Electrical Code (NFPA 70). All electrically powered equipment must always be properly grounded. For additional information refer to NEC (NFPA 70, Article 250).
- 4.2 Twin wire electric arc systems generate a high intensity arc to produce the heat required for spraying. This high amount of electric power (amperage and voltage) should only be handled by properly trained personnel.

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- 4.3 When working with a twin wire electric arc spray system, it is important to note that when the unit is on and running, the wires are electrically charged (one wire positive and the other negative). Care therefore must be taken not to touch the wires during this time.

- 4.4 Care should be taken when operating any electrical equipment in, around or near water.

5.0 HANDLING AND STORAGE OF MATERIALS

- 5.1 All materials should be handled with care and stored in a clean, dry environment. Material Safety Data Sheets (MSDS) are available from manufacturers and are provided with each material (wire, sealer) supplied. This is in compliance with the Occupational Safety and Health Act (OSHA) regulations published in the Code of Federal Regulations (CFR), 29CFR 1910.1200 which require that MSDS's be provided to users of hazardous materials.

6.0 HAZARDOUS MATERIALS

OSHA and groups such as the American Conference of Government Industrial Hygienists (ACGIH) and other government agencies have developed extensive lists of hazardous materials and have set workplace exposure limits. Inasmuch as standards change and new information becomes available from time to time, it is required that the information contained in the Materials Safety Data Sheet (MSDS) be consulted for the latest, up to date information.

- 6.1 It is important to note that although some thermal spray materials can be hazardous, safe operating and environmental conditions can be achieved through the use of proper ventilation equipment, training, and personal protective equipment. Certain spray conditions may also require the additional use of HEPA filtration.

7.0 COMMONLY SPRAYED – ALUMINUM & ZINC

- 7.1 The following materials are specifically listed because they are commonly sprayed. There are a number of other hazardous materials that may be used in the thermal spray process. Please always refer to the applicable Material Safety Data Sheet for additional information.

1. Fumes and Dust

The thermal spray process atomizes molten metals, creating dust and fumes that can be dangerous to the operator. Engineering controls such as dust collectors, ventilation, and air makeup units may be necessary to provide good spray coatings and to protect the operator's health and safety. These controls are in addition to proper respiratory protection requirements.

All finely divided metal particles are potentially ignitable and should not accumulate as dust in the spray environment. Materials such as aluminum, zinc, and other base metals may react with water to produce hydrogen, an explosive gas.

Proper exhaust control, training, and personal protective equipment must be utilized for the safe handling of these potentially hazardous materials.

2. Hazardous Wastes

Hazardous wastes can be generated from substrate preparation, the spray process and/or the finishing operation. All hazardous waste disposals must be disposed of in accordance with all federal, state and local guidelines.

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3. Flammable Sealers and Solvents

Certain degreasing solvents and sealer bases are flammable, and special precautions must be observed relative to their use, storage and handling. Solvents containing Class 1, Group D hydrocarbons (NFPA 70, Article 600) may decompose into noxious and toxic gases when exposed to ultraviolet light, which is present with the plasma and wire arc processes. Perchloroethylene and trichloroethylene can decompose very rapidly into the toxic phosgene (carbonyl chloride) gas when exposed to an electric arc.

4. Zinc and Zinc Alloys (Zinc Bronzes and Brasses)

Fumes of these metals can lead to a condition commonly referred to as the "zinc chills". Appropriate ventilation equipment and personal protective equipment must be utilized when spraying these materials.

5. Ultraviolet Light

The severity of flash burn depends on the duration of exposure, UV wavelengths, and the energy level at which the luminance and radiance are produced during the process. Eyes can be damaged without discomfort during exposure.

UV produced by thermal spray processes can affect exposed skin, causing sunburn, sun tanning, and changes in skin cell growth. Repeated exposure to UV may decrease skin elasticity. This can give the appearance of premature aging and can lead to a higher risk of skin cancer.

In a shop environment, it is important to install UV dark glass or shades over the windows of spray booths and enclosures. In an arc spraying environment the operators and others in the area should wear a minimum of No. 6 shaded lens when within a 15' radius of a working area. They also should place adequate barricades around open spray areas and never allow themselves or others to view the plume of a spray gun without adequate eye protection.

8.0 THERMAL SPRAY EQUIPMENT

8.1 Combustion Flame Spray Equipment

Combustion flame spray equipment uses oxygen and a fuel gas (Propylene and MAPP are most often used. Acetylene, propane, and hydrogen, may also be used.) which are combined and ignited under controlled conditions. The resulting flame is used to melt either wire materials which may be internally or externally injected into the flame. The semi-molten droplets are then propelled onto a prepared substrate/part and built up to form a coating of appropriate thickness.

Combustion spray processes require that care be taken in the storage / handling / use of the combustible gases that are necessary for these processes. Please refer to the previous section of this manual and relevant NFPA and CGA documents for gas handling safety guidelines.

9.0 HANDLING, STORAGE AND USE OF COMPRESSED GASES

9.1 Local, state and federal regulations relative to in-building use and storage of gas cylinders should always be observed. The improper storage, handling or use of gas cylinders can result in a serious safety hazard.

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- 9.2 **Oil or grease should never come into contact, or be used on, equipment which carries oxygen gas. Only approved lubricants should be used in these cases. An approved lubricant in this instance would be Krytox.**
- 9.3 The manifold of more than two gas tanks may be required to permit higher gas flows and longer spray times. Only approved pressure adjusting regulators should be used with each gas, and should never be over tightened or forced to make a connection. Gas regulator adjusting screws should be fully released prior to opening cylinder valves. Cylinder valves should be opened slowly to prevent surges that can damage other related equipment. When opening a gas cylinder, stand to the side of the pressure-reducing regulator, never in front of it.
- 9.4 It is dangerous and not recommended to use acetylene gas above 15 psig (free flowing).
- 9.5 The following guidelines should be followed when handling gas tanks:
1. Never drop tanks or knock tanks into one another. Some gases are unstable (i.e. acetylene) even when in the tanks. Remember, the gas does NOT want to stay in the tank!
 2. Gas tanks should always be secured to a wall or other supporting fixture with chains or similar restraints even when the tanks are not in use as they can easily tip over.
 3. Only transport tanks in proper carriers Gas carts are designed to move tanks around, dollies are NOT. Do not attempt to carry or drag tanks. .
 4. Never leave tanks in direct sunlight or extreme heat. Heat will cause the tank pressure to increase dramatically resulting in an unsafe situation.
 5. Never smoke around tanks. Although no leak may be apparent, some gas could be leaking and may ignite.
 6. Tanks should always remain upright. They are designed to be operated and transported in this position. If a tank is found lying on its side, carefully return the tank to its upright position. Allow the tank to remain upright for at least 30 minutes before attempting to use it.
 7. If a tank has been stored outside in a cold environment allow the tank to warm up at least one hour prior to use. A liquid tank (i.e. propylene) will require up to 4 hours to reach room temperature.
 8. The caps on the gas tanks should be on at all times when the tank is not in use. The cap is used to protect the weakest part of the tank; that being the tank head.
 9. Follow local guidelines and recommendations from the gas supplier for the allowable location of combustible gas tanks storage.

10.0 COMPRESSED AIR

Compressed air for thermal spraying should be clean and dry and never used for the cleaning of clothing or breathing purposes. The air line should be free of oil, dirt and moisture.

11.0 GAS REGULATORS

- 11.1 A regulator is a device that accepts gas at a high pressure and reduces it to a much lower working pressure. Regulators are made to withstand the full gas pressure within the cylinder, and yet can maintain effective control over the outlet pressure

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- 11.2 Regulators are precision instruments containing machined components which must be handled with care. Avoid rough treatment of these devices which can result in damage to the inner springs, diaphragms, valve seats, etc.
- 11.3 There are several types of regulators available on the market, with each one being designed and assembled for a specific gas and inlet and delivery pressure range. Check that the regulator is suitable for use for the required pressure ranges and gas type that is being used.
- 11.4 Air or nitrogen regulators must not be used with oxygen and vice versa. Where air is supplied directly from compressors, the compressed air could contain traces of oil which can contaminate a regulator and could be extremely dangerous if used with oxygen. Oil or grease must never come into contact with any regulator, cylinder, and pipeline valve or associated fittings that are to be used with oxygen gas. Never handle oxygen gas equipment with oily or greasy hands, gloves or rags.
- 11.5 Some regulators reduce pressure from a high level to a lower level in a single stage, while others do this in two stages (multi stage regulator).
- 11.6 Please refer to the appropriate regulations when using a regulator and make sure that each operator reads and understands all applicable regulations and instruction manuals when handling these devices.
- 11.7 When spray work has been completed or the equipment is shut down, the gas supply must be turned off and all gases should be drained from the hoses.

12.0 FLOW METERS

Flow meters should be installed and used with proper gas regulators. All flow meters should be equipped with a protective shield between the meter and the operator and back flow arrestors should be used especially if the high velocity oxygen fuel (HVOF) process is being used.

13.0 GAS HOSES AND PIPING

- 13.1 The gas supply installation must be carried out by qualified personnel and must comply with the regulatory requirements applicable to the location of the spray cell set-up.
- 13.2 Old gas hoses that are dry or cracked should never be used. Hose connections should never be over tightened, this will cause the hose stem to collapse and restrict gas flow.
- 13.3 When proper gas flows cannot be obtained, check for obstructions in the gas hoses, nozzles, siphon plugs or air caps.
- 13.4 Flame spray guns or torches should never be hung on cylinder valves or regulators. This practice may result in a fire or explosion.
- 13.5 When lubricating o-rings, an inert lubricant such as Krytox should be used.
- 13.6 When spray work has been completed or the equipment is shut down (i.e. overnight, over a weekend), all gases should be drained from the hoses and regulator adjusting screws backed out.

NOTE: Only Grade T hoses may be used for fuel/gas.

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14.0 FLASHBACK ARRESTORS (COMBUSTION FLAME SPRAY)

A flashback occurs when a mixture of fuel gas and oxygen combine and burn within the hose. The resulting flame travels towards the gas source at a very high speed and can result in a fire or explosion in either or both the oxygen or fuel gas cylinders. Flashback arrestors should be fitted to the regulators on both gas cylinders. The common reasons for a flashback are:

- Incorrect purging of the hose and torch prior to use
- Incorrect gas pressure
- Incorrect nozzle
- Damaged torch valves allowing cross flow feeding of the gas within the torch
- Gas passages within the torch are blocked
- Kinked or trapped hoses

14.1 A flashback has two components, the flame front and a pressure wave. When the flame front enters a flashback arrestor, it passes first through a fine or closed sintered metal flame filter. This absorbs the heat of the flame thus "quenching" it (extinguishing the flame).

14.2 Once the flame is put out, it also is necessary to cut off the gas supply. The second element of a flashback, the wave, causes a pressure plate to be lifted causing the cutoff valve to operate. Depending upon the model and type of flashback arrestor, a "pop-up" button or lever may indicate that the cutoff valve has been activated.

14.3 If a flashback arrestor has been dropped or damaged, it may not work properly. Once damaged, these arrestors must be replaced.

14.4 Flashback arrestors must only be used with the gas that they are labeled for. Oxygen flashback arrestors have been specially de-greased.

14.5 The regulators in the flame spray system have a check valve mounted in the stem of the outlet side of the regulator. The check valve acts as a flashback arrestor in this system.

There are several approaches that may be taken to assure that a flame arrest system is in place. The example shown is one way of installing flashback arrestors.



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15.0 LEAK CHECKS

Leak checks should be made during the initial system pressurization and regularly thereafter.

15.1 A typical leak check procedure is sequenced as follows:

- Turn on the O₂ and Fuel and set the pressures to normal operating conditions
- Wait at least 2 minutes for the hoses to normalize
- Turn off the O₂ and Fuel and note the pressure on the primary side of the pressure regulators (the gauge closest to the bottle side/inlet of the pressure regulator)
- Examine the primary gauge closely over a time span of approximately 5 minutes. If there is a notable drop (more than half the starting pressure) within in that 5 minute time frame, that is indicative of a leak in the system
- Use the Snoop (soap bubble test) to isolate the leak

Please refer to your equipment manual or contact the manufacturer field representative for specific procedures on leak checking point sources of leaks. Leak testing should be performed with approved materials such as Snoop or other non-residual solutions.

15.2 Be sure to remove leaking or defective equipment immediately from service. Never attempt to repair gas regulators; regulators must be serviced by qualified gas repair facilities. Your local gas supplier can provide a list of qualified repair stations.

16.0 GAS DETECTION SYSTEMS

The gas detection system is not intended to deem the process area safe from hazardous conditions, but only to act to warn of unsafe conditions. Gas detection systems that can detect the extremely hazardous condition of a gas leak could be installed in and around the spray area if warranted. These systems can be programmed to warn personnel when a gas leak (unacceptably high amounts of gas) is detected and to signal for shut-off the supply of gas to eliminate the hazard. Gas detection systems help to provide an additional level of security when handling the combustible gases that are required for the thermal spray process. A continuous LEL meter must be used in any areas where a hot work permit is required by the client or where flammable materials are stored, used and transferred.

17.0 ARC SPRAY

17.1 Twin Wire Arc Spray Equipment

The arc gun systems require other equipment not associated with the combustion flame spray process since they use high voltage and amperages representing a potential electrical hazard. Periodic inspections of cables, hoses and gas lines should be made and equipment replaced as necessary. No adjustments, cleaning or repair should be made to any part of the system before disconnecting the main electrical power supply.

17.2 The accumulation of metal dust in the arc power supply unit and gun requires frequent cleaning to avoid short circuits.

17.3 All exposed electrical connections should be properly insulated and protected to avoid electrocution.

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- 17.4 The electric arc from arc equipment produces both nitrous oxide and ozone in the air. The amount of nitrous oxide or ozone in the air may exceed the workplace exposure limits when in a confined space with limited ventilation.

18.0 MAINTENANCE OF SPRAY EQUIPMENT

WARNING: EXTREME FIRE AND EXPLOSION HAZARD

When dealing with combustion flame spray equipment, only use materials and components approved for oxygen service. Most rubber and elastomer gaskets are NOT compatible with oxygen. Many metals and alloys are not suitable for oxygen service. Lubricants, as a rule, should be avoided. Refer to the manufacturer's operation and maintenance manuals to identify materials and equipment approved for use during the maintenance of TSA equipment.

- 18.1 All spray guns should be set-up, operated and maintained in accordance with the manufacturer's recommendations to avoid operational difficulties, unsafe conditions and annulment of warranties. Each gun has its own unique operating conditions due to the variation of design and function. All operation manuals should be thoroughly read and understood by every member of the spray team prior to any spray work.
- 18.2 All equipment repair work must only be performed by qualified specialists. Troubleshooting of the electrical system and its components should only be performed by a qualified specialist. All Brand requirements for performing repairs should be followed per the safety manual, specifically LOTO.
- 18.3 It is highly recommended that each piece of equipment have its own cleaning / servicing / repair log book that is kept up to date and reviewed regularly.

19.0 AUXILIARY EQUIPMENT

19.1 Abrasive Blast Equipment

Indoor blasting should always be conducted inside of an enclosed cabinet or blast room to prevent flying abrasives from injuring personnel. Ventilation and dust collection equipment is also required when blasting indoors. See PSG–SM–26 Abrasive Blast Procedure for these guidelines.

- 19.2 Brand prohibits use of silica sand as an abrasive source for our employees' use.

20.0 VENTILATION SYSTEMS (SHOP SYSTEM)

- 20.1 Thermal spray processes produce fume and dust particles from the materials being sprayed. To avoid the effects of dust and fumes generated by spraying, a suitable spray booth and sufficient exhaust system may be required at some locations. Outdoor work locations may be performed without fire barriers, enclosures, and mechanical ventilation only when NOT considered hot work.
- 20.2 When dust collectors are utilized they should be provided with explosion vents or rupture disks in case of explosion. All fans, pipes, dust collectors and motors shall be approved and electrically grounded to avoid spark ignition.

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- 20.3 When cleaning booths, pipes, etc., proper ventilation of the area is necessary in order to prevent the accumulation of fumes or dust. Non-sparking tools should always be used in cleaning and repair operations when an accumulation of dust is present. When emptying the collector, all sources of ignition in the area and around the collector should be eliminated. When making repairs, no welding or cutting should be done before the equipment is washed down and all metal dust removed.

21.0 AVOID HAZARDOUS CONDITIONS

- 21.1 Combustible materials such as wood and paper should not be used in the vicinity of the exhaust system. Dust Collectors do not usually contain fire extinguishing equipment. However, fire extinguishing equipment can be incorporated into dust collectors, upon request. Please contact a manufacturer representative for more information.
- 21.2 When dust collectors are used to collect flammable or explosive dusts (such as aluminum or zinc), the collection container should be located outside the building. All local, state and national fire codes must be complied with when determining the location of the exhaust ventilation system.
- 21.3 Always avoid spraying directly into the exhaust opening and be sure to maintain a 3 foot (1 meter) minimum distance from the gun to the duct opening to help minimize fire hazards.
- 21.4 The dust collection system should be properly maintained and inspected on a regular basis. Waste drums must be regularly emptied or changed and thermal spray dust should be treated as a hazardous material.
- 21.5 For recommended air exchange rates for your booth size, please contact the HVAC System Sales Service department where obtaining the ventilation equipment.

22.0 PERSONAL PROTECTION

When thermal spraying, personal safety is the responsibility of the user and he/she must always be aware of all of the hazards that may be present (i.e. eye, skin, hearing, respiratory). All Personal Protective Equipment must be in accordance with OSHA 29 CFR 1910.132 and all of the manufacturer's safety standards and instructions for material and equipment handling must be followed. Material Safety Data Sheets (MSDS) are available from spray material manufacturers and should be read and understood prior to material use.

22.1 Eye Protection

Eye protection is required for all spray equipment due to the presence of ultraviolet and infrared radiation. All eye and face protective equipment must be in accordance with OSHA 29 CFR 1910.133.

- 22.2 For arc spraying, a welding helmet or blasting hood is required to provide sufficient protection of the face and eyes. For combustion flame spraying, shaded safety glasses are required. The following list should be used for selection of appropriate lens shade:
- | | | |
|----|--|------------|
| 1. | Wire Flame Spray (Thermal Spray) | Shades 2-5 |
| 5. | Plasma and Arc Spraying (up to 40KW) | Shades 6-9 |
- 22.3 Eye protection is also necessary to protect from flying or airborne matter such as dust or powder residue.

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23.0 RESPIRATORY PROTECTION

- 23.1 Spray and blast operations may require (see Sections 6.0 and 31.4) that a respiratory protection device be used by the operator. The nature, type, and magnitude of the fume and gas involved determine which type of respiratory protection device is required. All devices selected should be ANSI approved and should be appropriately fitted to the individual after appropriate medical surveillance. Respiratory devices must be cleaned and well maintained and should never be transferred from one user to another. Training and fit testing must be performed on an annual basis.
- 23.2 Typical requirement for respiratory protection is ½ Face, Negative Pressure Mask with HEPA cartridge.
- 23.3 Fumes and gases produced by the thermal spray process can severely harm one's health. Hazardous materials may exist in certain feedstock materials and these materials as well as by-products of these materials may be released into the air during the spray process.

24.0 NOISE PROTECTION

- 24.1 OSHA's hearing conservation program, which is designed to protect workers with occupational noise exposure, requires employers to provide employees who are exposed to an eight hour time weighted average (TWA) of 85 dB or above with a hearing conservation program. Training on appropriate use and maintenance of the hearing protection is also mandated by OSHA. Please refer to OSHA 29 CFR 1910.95 for appropriate guidelines on Occupational Noise Exposure.
- 24.2 The physiological effects of noise are caused by the intensity (loudness) and duration. The louder the noise, the shorter the permissible exposure. The table shown below gives an approximate intensity level for each thermal spray process.
- 24.3 If possible the spray operation should be isolated from the operator. If this is not possible, personnel should be rotated so that exposure is maintained at an acceptable level. The noise level at any location depends on factors such as equipment, operating parameters, background noise and room size, as well as floor and ceiling materials. To determine the exact noise level, on site test measurements should be performed in accordance with OSHA regulations. Double Hearing protection is required if working within 15' of spray operator.

EQUIPMENT	SET-UP	DECIBEL LEVEL dB
Twin Wire Electric Arc Guns	Steel 24V / 200 A	111
	Steel 32V / 500 A	116
Powder Guns	Acetylene w/o spray booth	89-93
	Acetylene w/spray booth	90-94
	Acetylene w/spray booth and air jet cooling	111
	Hydrogen w/o spray booth	100
	Hydrogen w/spray booth	101
Wire Combustion Guns	Acetylene	114

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(1/8 in. and 3/16 in. wire)	Propane	118
	Propane and non-load hardware	125
Plasma Guns	Nitrogen – 600 A	135
	Nitrogen / Hydrogen – 600 A	133
	Argon – 1000 A	128
	Argon / Hydrogen – 600A	132
	Argon / Helium – 600A	127
	Argon / Nitrogen – 1000A	131
HVOF Guns	Standard Diamond Jet (all gases)	130
	Diamond Jet Hybrid (all gases)	140
Typical Grit Blasting Equipment		80-85
Typical Exhaust Equipment		>90

25.0 PROTECTIVE CLOTHING

- 25.1 Appropriate protective clothing is required for any spray or blast operation (including robotic blasting/spraying and chamber spraying) under OSHA 29 CFR 1910.132. The specific type of clothing is dependent upon the nature of the work being performed.
- 25.2 The intense ultraviolet radiation of plasma or arc spray has been known to burn skin even through normal clothing. Thick or heavy clothing, such as smocks or coveralls, are therefore required.
- 25.3 When working in confined spaces, flame resistant, cuffless clothing shall be worn. In addition, leather aprons or leather sleeves may also be used. Gloves should be leather with cuffs extending beyond the wrist. Tight fitting clothing is also recommended to keep grit, powder and spray reacted materials and dusts from coming in contact with the skin.
- 25.4 Metallized dust and fumes may cause allergic reactions or other health related disorders and therefore workplace exposures should be minimized through the use of engineering controls, training, and personal protective equipment.
- 25.5 It is also recommended that before handling food, face and hands should be thoroughly washed with soap and water to remove any powder debris. Never use a compressed air line to blow off dust from clothing. This may cause fine metal dust to spontaneously combust and potentially cause severe burns.

26.0 CODES AND REGULATIONS

- 26.1 This section is designed to provide relevant information and links on codes and regulations governing the design, manufacture and use of thermal spray products.
- 26.2 Globally there are numerous regulating bodies that cover both the installation and operation of thermal spray equipment and the use of thermal spray materials such as powders and wires. In general thermal spray is classed as an industrial process and comes under the governing bodies with respect to the application of industrial equipment.

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- 26.3 There are two types of regulating bodies: The first type are either professional organizations or groups that create guidelines they recommend being followed in order to ensure safe operation of a device, utility, or service. The second types are usually governmental departments responsible for enacting into law the requirements set forth in certain guidelines. The latter often adopts the guidelines of the former.

27.0 REGULATING BODIES

- 27.1 Regulating bodies are as follows:









1. NFPA - The National Fire Prevention Association is responsible for the adoption and enforcement of safe designs and installation of potentially hazardous devices and includes the National Electric Code to which all electrical equipment must meet as a minimum.
www.nfpa.org
2. OSHA - The Occupational Safety and Health Administration is tasked with ensuring that work places are as reasonably safe as possible. Material Safety Data Sheets (MSDS) are an OSHA requirement as well as the publication and notification of worker hazards in both materials and equipment.
www.osha.gov
3. ANSI - American National Standards Institute is responsible for establishing guidelines for equipment design and operation that are utilized by OSHA and other regulatory agencies. These guidelines include risk analysis using a standard format and the safe design/application of robotic systems.
www.ansi.org
4. CGA - Compressed Gas Association develops guidelines utilized by both the NFPA and OSHA for the safe handling of compressed gasses including potentially hazardous gasses such as Hydrogen.
5. NIST - National Institute of Standards and Technology is responsible for establishing standards for the implementation and operation of emerging technologies. This group is most popular for the development of standards for the process of ensuring equipment calibrations and traceability.
www.nist.gov
6. MILSPEC - Military Specifications developed by the US government govern the design and application of many industrial products as the specifications were adopted over time.
7. astimage.daps.dla.mil
8. NEMA - National Electrical Manufacturers Association develops guidelines and design specifications for electrical equipment, primarily with electrical switchgear such as enclosures, switches, and disconnects. Many of the requirements are incorporated into the National Electric Code and other requirements in industry.
www.nema.org

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In addition to the governing bodies above there are numerous professional organizations that formulate safety guidelines and standards for complex machinery including Robotics International, Society of Manufacturing Engineers, and the National Machine Tool Builders Association.

28.0 SAFETY SYMBOLS














- 28.1 The following safety symbols may be found in documents, such as technical manuals and product labeling, to alert the user to the presence of important operating instructions, safety considerations and special instructions. Whenever these symbols are encountered, the user should read, understand and proceed in accordance with the definition provided below:

GENERAL INFORMATION AND WARNINGS	
Presentation of general, but important information which should be read and understood prior to proceeding.	
General hazard warning which can result in minor personal injury or minor damage to machinery.	
Danger! Failure to comply can result in severe personal injuries or death.	
Mandatory requirement not covered by other symbols.	
Protective Footgear must be worn.	
Protective Clothing must be worn.	
Sound attenuating ear protection must be worn.	
Eye protection must be worn.	
Respiratory protection must be worn.	



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Hand protection must be worn.	
Head protection must be worn.	
Face protection (welding gear) must be worn.	
Keep hands, hair, clothing and tools away from moving parts.	
WARNINGS	
Warning of hazard which can result in severe personal injury or severe damage to machinery.	
High Voltage or risk of electric shock present.	
Explosion hazard, explosive material present.	
Flammable material or presence of high temperatures.	
Ultraviolet, infra-red or other damaging light radiation present.	
Warning of laser present.	
Strong electromagnetic fields present.	
Noise hazard present.	
Do not stack warning.	

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High pressure warning.	
Poisonous substance present	
Heavy weight present above	
Electrical ground is not present	
Corrosive material (this symbol may appear on material product labels.	
Material is hazardous to the environment (this symbol may appear on material product labels)	
Explosive material present (this symbol may appear on material product labels)	
Highly flammable material (this symbol may appear on material product labels)	
Irritant Present (this symbol may appear on material product labels)	
Oxidizing material present (this symbol may appear on material product labels)	
Poisonous Material Present (this symbol may appear on material product labels)	
PROHIBITORY	
Fire and open flames prohibited	
Use of grease or lubricants prohibited.	

TSA PROCEDURE – APPLICATION OF THERMAL SPRAY COATINGS

Use of pacemakers is prohibited.	
Smoking is prohibited.	

29.0 PHYSICAL AND HEALTH HAZARDS

29.1 Fire/Explosion

Extreme care must be used when applying thermal spray coatings on hydrocarbon containing equipment to avoid igniting leaks at flanges, valve packing and other potential sources. Where work area conditions include hydrocarbon service the following steps must be taken:

- Continuous LEL monitor
- Spark containment barrier/fire blankets Fire suppression equipment.
- Trained fire watch assigned

29.2 Explosion

In confined or contained spaces, an explosive concentration of metal dust may form by the use of this process.

29.3 Burn

Contact with this hot material may cause serious burns.

29.4 Inhalation

This application may produce hazardous concentrations of metallic dust or fumes as well as carbon monoxide.

29.5 Electrical

This process could be a source of electrical shock. Area must be surveyed and protective measures taken to assure area is free of water/moisture.

29.6 Deluge systems must be identified and control measures taken to prevent potential sources of water from entering the work area during work process. Specific mitigation steps to isolate or re-direct water streams must be acceptable to equipment / unit owners.

29.7 Radiation

Intense ultraviolet (UV) and infrared (IR) radiation occurs with these processes.

29.8 Noise

Sound levels produced by Arc and Thermal Spraying operations can be as high as 120 decibels.

29.9 Magnetic Fields

Magnetic fields from high electrical currents can affect pacemaker operation (**Arc Spray Only**).

TSA PROCEDURE – APPLICATION OF THERMAL SPRAY COATINGS

30.0 HAZARD MITIGATION

- 30.1 Fire blankets/boxes should be used as appropriate to reduce or contain the sparks generated by this process.
- 30.2 A hot work Class D, 20 lb. fire extinguisher is the minimum fire protection. A "Fire Watch" must be assigned to all work where hot work permits are required.
- 30.3 An air mover needs to be installed to prevent dust and CO accumulation if the application of TSC is in an area of poor ventilation. 100-200 CFM of air movement is sufficient when working outside.
- 30.4 Areas must be barricaded using red barricade tape a minimum of 15 feet around the work area. The contractor shall attach signs on each side of the barricaded area stating "Danger - Thermal Spray Coating being applied. Do Not Enter" (See Figure 3 for example of sign).

31.0 VENTILATION

Large amounts of fresh air are the best prevention against exposure to carbon monoxide and metal fumes or dust. Respirators, local exhaust or forced ventilation are also effective in preventing exposure.

31.1 Good Ventilation

- 1. Natural ventilation in large open areas.
- 2. Exhaust or forced air ventilation in field shops.

31.2 Marginal Ventilation

- 1. Field enclosures that restrict natural ventilation such as wind breakers or a boxed in scaffold with the top open.
- 2. Not using exhaust vents in shops due to physical restriction of the work piece.
- 3. Unrestricted airflow and distribution in vessels and furnaces. (Unrestricted means no major structural packing/tray structures or scaffolds present as barriers to flow.)
- 4. Shallow trenches.

31.3 Poor Ventilation

Restricted air flow and distribution in vessels is possible. Examples include visible accumulation of fumes, working at multiple levels in a single vessel, short circuiting of air flow by open manways or no manways to affix exhaust air movers.

Notes:

- 1. Maintain 2000 cfm air flow per applicator inside a vessel or enclosed space. Contact IH for options on achieving required air flows.
- 2. Respirator use is recommended for all personnel present in vessels or confined spaces with marginal or poor ventilation while TSA is in progress.
- 3. If 2000 CFM flow per applicator cannot be achieved in a vessel, all personnel in the vessel require supplied air, unless the vessel can be adequately segmented. Contact IH for options.

TSA PROCEDURE – APPLICATION OF THERMAL SPRAY COATINGS

31.4 When applying TSC's, the operator shall wear the following PPE:

1. Leather gloves with cuffs extending beyond the wrist.
2. High top, steel-toe shoes with cuffless FRC pants that cover the shoe tops.
3. Respiratory protection as follows:

a) **Arc Spray**

NIOSH approved Type CE air-fed blasting hood. A Welder's hood with appropriate respiratory protection may be used by workers within 15' of operator.

Note: Verify that the location of the breathing air intake is free from contamination and that periodic air quality checks are performed.

b) **Flame Spray**

Filter-type air purifying respirators may be used in situations with good ventilation. NIOSH approved Type CE air-fed blasting hood or welder's hood with approved respiratory protection in situations with marginal or poor ventilation.

4. Face/Eye protection

See section 5.1 of this procedure.

a) **Arc Spray**

Safety goggles with No. 6-9 filter shades (without arc shield attached to hood) or No. 3-5 filter shades with arc shield attached to hood.

b) **Flame Spray**

Safety goggles with No. 2-5 filter shades.

5. Hearing Conservation – Arc & Flame Spray

Wear double hearing protection in the form of ear plugs and muffs when within 15' of the work piece. This includes applicator and any other craft.

31.5 Other personnel inside the barricaded work area shall wear the following PPE:

- Filter-type air purifying respirator for dust exposures,
- Safety glasses with No. 3-5 filter shades, and,
- Double hearing protection.

31.6 Any 3 phase AC power cable shall be run in a conduit or type CLX metal jacketed cable, unless other controls/barriers are approved by the Technical Services Department electrical contact engineer or electrical specialist (Arc Spray Only).

31.7 A Ground Fault Circuit Interrupt (GFCI) device is required in any 110 - 120 VAC power supply used for cord and plug connected equipment.

31.8 Protective covers shall be in place to prevent direct contact with the metal wire or wire spools while the TSC equipment is energized (Arc Spray Only).

TSA PROCEDURE – APPLICATION OF THERMAL SPRAY COATINGS

- 31.9 No attempt should be made to adjust, clean, or repair any part of the power supply, console or TSC spray gun while the equipment is energized.
- 31.10 Electrical equipment shall be adequately grounded.

32.0 ATTACHMENTS

- Form A, Procedure Step Checklist
- Appendix A, Typical Thermal Arc Spray Equipment Setup
- Appendix B, Typical Flame Spray Equipment Setup
- Appendix C, Typical TSC Barricade Sign

TSA PROCEDURE – APPLICATION OF THERMAL SPRAY COATINGS

FORM A

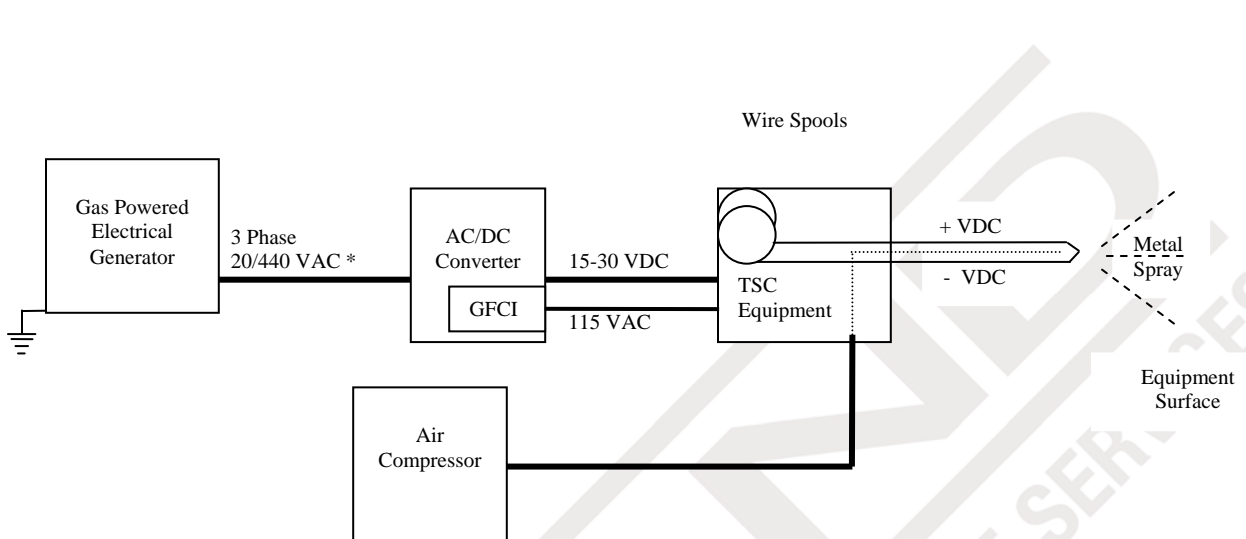
PROCEDURE STEP CHECKLIST

Item	Yes	No	Action / Comment
1. Identify the equipment on which the TSC will be applied and the extent of work area to be barricaded.	<input type="radio"/>	<input type="radio"/>	
2. Identify the location to stage the compressor supplying breathing air for the operators' hood. – Arc Only.	<input type="radio"/>	<input type="radio"/>	
3. Install red barricade tape and post signs (see figure 3) along the 15 foot perimeter around the tsa application.	<input type="radio"/>	<input type="radio"/>	
4. Install fire boxes and/or blankets as appropriate to contain the "sparks" generated by the TSC application. Continuous LEL meter where required on "Hot Work Areas"	<input type="radio"/> <input type="radio"/>	<input type="radio"/> <input type="radio"/>	
5. The technical services department electrical engineer or electrical specialist shall inspect the installation of all portable equipment and cables supplying ac power (arc spray only).	<input type="radio"/>	<input type="radio"/>	
6. Verify that the required fire protection is at the work site including trained fire watch where applicable.	<input type="radio"/>	<input type="radio"/>	
7. Verify that proper guards are in place and being used during operation of the tsa equipment to protect personnel from electrically energized surfaces.	<input type="radio"/>	<input type="radio"/>	
8. Verify that air movers have been installed and are being used if poor ventilation may result in the accumulation of metal dust.	<input type="radio"/>	<input type="radio"/>	
9. Verify that the operator and other personnel working within the barricaded area are using proper PPE.	<input type="radio"/>	<input type="radio"/>	
10. Verify whether deluge system exists, and that approved mitigation steps are in place to prevent unexpected release of water into the work area.	<input type="radio"/>	<input type="radio"/>	

TSA PROCEDURE – APPLICATION OF THERMAL SPRAY COATINGS

APPENDIX A

TYPICAL THERMAL ARC SPRAY EQUIPMENT SETUP

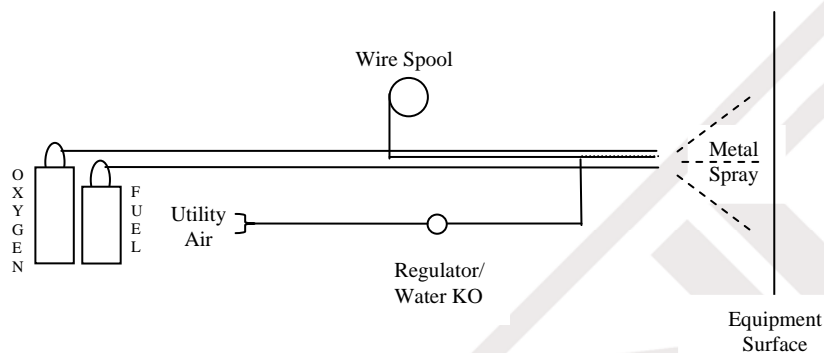


* Unless other controls/barriers are approved by the Technical Services Department electrical contact engineer or BREO electrical specialist, power cable shall be run in conduit or CLX metal jacketed cable.

TSA PROCEDURE – APPLICATION OF THERMAL SPRAY COATINGS

APPENDIX B

TYPICAL FLAME SPRAY EQUIPMENT SETUP



TSA PROCEDURE – APPLICATION OF THERMAL SPRAY COATINGS

APPENDIX C

TYPICAL TSC BARRICADE SIGN FOR ARC SPRAY TSC



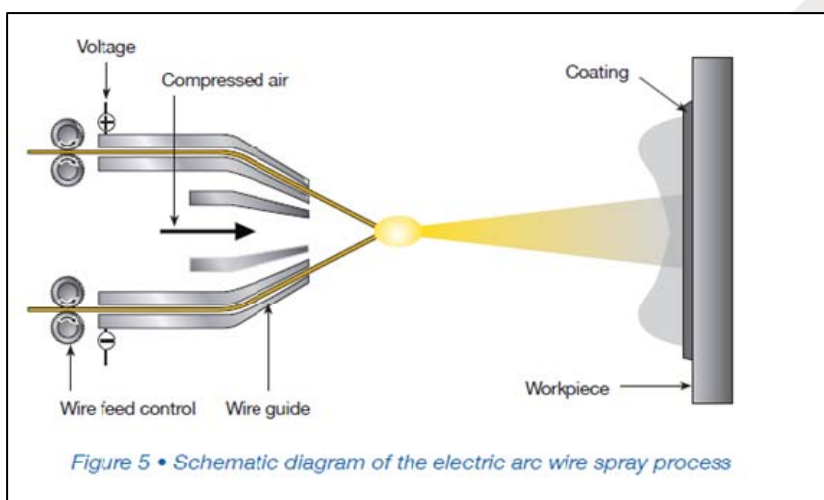
Sign colors and format to conform to the requirements for "Danger" signs found in ANSI Z535.2, "Environmental and Facility Safety Signs".

TSA PROCEDURE – APPLICATION OF THERMAL SPRAY COATINGS

33.0 REFERENCES

- Respiratory Protection PSG-SM-9
- Hearing Protection PSG –SM -23
- Abrasive Blasting PSG – SM-26

34.0 ARC SPRAY SCHEMATIC

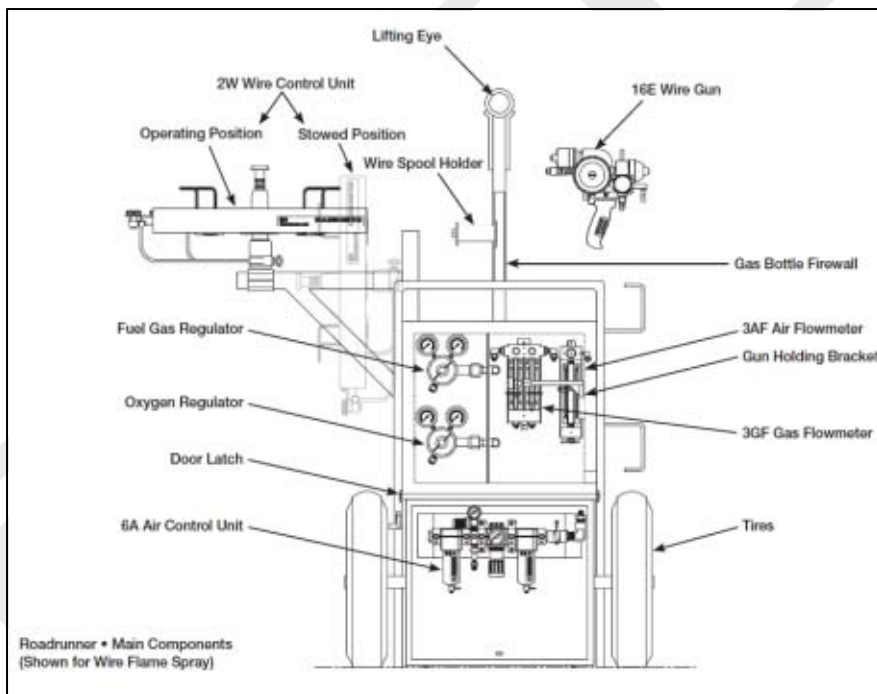
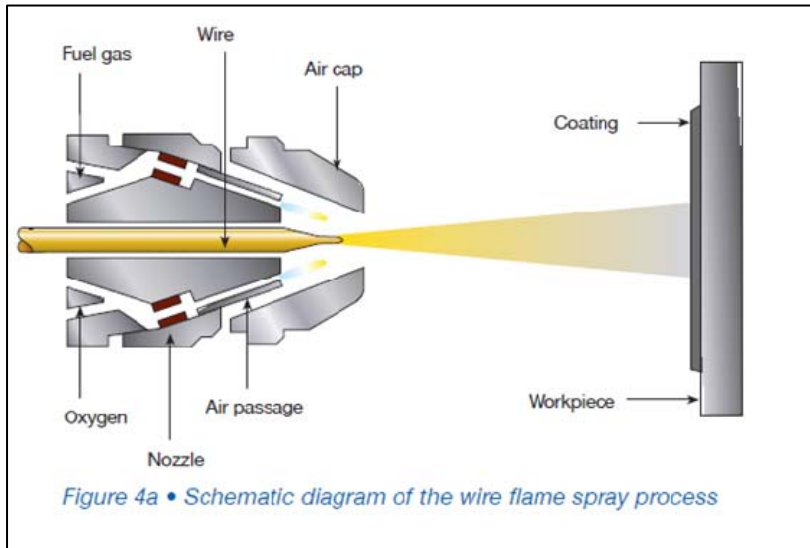


35.0 ARC SPRAY EQUIPMENT



TSA PROCEDURE – APPLICATION OF THERMAL SPRAY COATINGS

36.0 FLAME SPRAY SCHEMATIC



TSA PROCEDURE – APPLICATION OF THERMAL SPRAY COATINGS

37.0 FLAME SPRAY EQUIPMENT



TSA PROCEDURE – APPLICATION OF THERMAL SPRAY COATINGS**FORM B****ARC SPRAY – TSA MACHINE****DAILY EQUIPMENT INSPECTION FORM**

DATE:	INSPECTED BY:
MAKE / MODEL:	UNIT ASSIGNED TO:
EQUIPMENT #:	FOREMAN:
CONTRACTOR NAME:	

INSPECTED	PASS	FAIL	REPAIR	N/A	COMMENTS
PRECISION ARC METER PANEL COMPONENTS:					
1. Meter Panel Assembly AMP / Volt Gauge	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
2. Meter Panel Dial Plate / Knobs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
3. Meter Panel Inch / Air Switch	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
4. Meter Panel Switch Boot	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
5. Meter Panel Air Hose / Quick Disconnect	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
6. Meter Panel Trigger Cord Socket	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
PRECISION ARC SPRAY HEAD PANEL COMPONENTS:					
1. Trigger and Handle	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
2. Arc Spray Head Shield	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
3. Center Air Nozzle Tip / O-Ring	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
4. Side Air Jets	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
5. Head Contact Tubes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
PRECISION ARC WIRE DRIVE COMPONENTS:					
1. Wire Drive Spring Knob Assembly	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
2. Wire Drive Replacement Fork	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
3. Wire Center Guide and Clamp	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	

TSA PROCEDURE – APPLICATION OF THERMAL SPRAY COATINGS

FORM B – ARC SPRAY – TSA MACHINE DAILY EQUIPMENT INSPECTION FORM (PAGE 2 OF 2)

INSPECTED	PASS	FAIL	REPAIR	N/A	COMMENTS
4. Wire Drive Insulated Gear Assembly	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
5. Clapper Assembly	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
6. Wire Straightener Assembly	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
7. Motor Assembly / Hour Meter	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
8. Motor and Drive Assembly	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
9. Feed Liner and Nuts	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
PRECISION ARC CONTROL BOX ASSEMBLY:					
1. Control Box Housing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
2. Control Box 14 Pin Cords	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
3. Control Box Cord Keeper Lock Fittings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
PRECISION ARC EQUIPMENT OPERATING CHECK:					
1. Power Supply Setting On #8	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
2. Feed Motor Speed Control Set on #4	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
3. Air Supply Minimum 90 PSI	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
4. 110 VAC Indicator Light is Illuminated	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
5. Adjust Potentiometer to 1/8" to 1" Runback Time	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
Additional Comments:					

Signature:	Date:
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TSA PROCEDURE – APPLICATION OF THERMAL SPRAY COATINGS

FORM C

FLAME SPRAY – TSA MACHINE

DAILY EQUIPMENT INSPECTION FORM

DATE:	INSPECTED BY:
MAKE / MODEL:	UNIT ASSIGNED TO:
EQUIPMENT #:	FOREMAN:
CONTRACTOR NAME:	

INSPECTED	PASS	FAIL	REPAIR	N/A	COMMENTS
FLAME SPRAY TSA EQUIPMENT:					
1. Wire Feed Assembly	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
2. Gas Head Valve	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
3. 16-E Gun Safety Handle and Trigger	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
4. Gas Valve Fittings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
5. Overall Gun Condition (Bolts, Rivets, Trigger Head)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
6. Siphon Housing Condition	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
7. Nozzle and O-Ring Seal Condition	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
OXYGEN PROPYLENE CABINET:					
1. Wheels & Nuts	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
2. Gauges	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
3. Hose Fittings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
4. Hose Conditions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
5. Whip Checks	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
6. Oxygen / Propylene Separation Wall Plate	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
7. Lifting Lug	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
8. Safety Latches & Pins	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	

TSA PROCEDURE – APPLICATION OF THERMAL SPRAY COATINGS

**FORM B – FLAME SPRAY – TSA MACHINE
DAILY EQUIPMENT INSPECTION FORM
(PAGE 2 OF 2)**

INSPECTED	PASS	FAIL	REPAIR	N/A	COMMENTS
OPERATING CHECK:					
1. Gas Flashback Arrestor Propylene Valve	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
2. Gas Flashback Arrestor Oxygen Valve	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
3. Gas Flow Meter Operational	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
4. Oxygen Flow Meter Operational	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
5. Check Fitting / Gauges / Meter for Leaks	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
Additional Comments:					
Signature:					Date: